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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Gas Engine Lubrication

Cylinder Lubrication

Cooling—The Relation to Lubrication

PUBLISHED BY

THE TEXAS COMPANY

TEXACO PETROLEUM PRODUCTS

TEXACO LUBRICANTS
FOR
GAS ENGINE SERVICE

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THE TEXAS COMPANY

Texaco Petroleum Products

135 East 42nd Street, New York City

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Gas Engine Lubrication

UTILIZATION of gas power as a means of driving the internal combustion type of engine has been practiced more or less extensively over the past sixty years. In part its development may be said to have been accelerated by the excess of fuel resulting from the expansion of the steel industry during that time; the gas engine affording a ready and economical means of using the potential power supply available through blast furnace operations, thereby to reduce waste of heat units. Almost simultaneously this type of engine was proved to be quite as capable of functioning on other types of inflammable gas such as producer gas, illuminating and coke oven gas.

It remained for the petroleum industry, however, to extend this type of prime mover to natural gas. Until today in certain of the petroleum producing centers of the world, the gas engine has become the predominating means of power development. And yet, when we take into account the almost unbelievable volume of natural gas available, its use as above is virtually in its infancy.

This has been aptly brought out by Ames* in his paper on "Petroleum and The Law", wherein he states that:

"Approximately two billion cubic feet of gas are being blown into the air every day. In 1930 there were 5,448,000 domestic consumers of natural gas who used a total of 376,407,000,000 cubic feet, or a little more than one billion cubic feet per day. We are, therefore, blowing into the air approximately twice as much natural gas as is being used by 5,448,000 domestic consumers. This is a three-fold waste. It wastes the gas itself, but the gas which is being wasted is bringing to the surface an excessive quantity of oil which results in wasteful use and inadequate price, and in addition, this wasted gas is bringing to the surface its natural gasoline content which, in turn, is crowded into an unwilling market to the detriment of the industry as a whole."

One of the most practicable means of reducing this waste, is to utilize the fuel value by extended usage of the gas engine as a prime mover. This would tend furthermore to conserve our coal resources, particularly in localities where coal deposits are remote and where transportation may frequently become a costly problem.

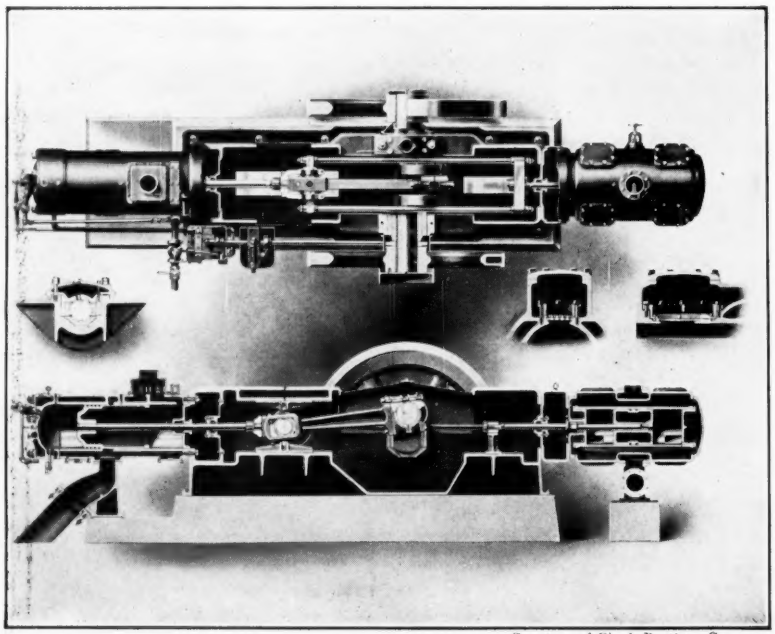
The gas engine is distinctive by reason of its flexibility and its adaptability to a wide variety of operating conditions. It can be constructed to function either horizontally or vertically, to develop up to 2000 H.P. per cylinder. Operating speeds are normally low, the maximum being generally around 350 R.P.M. Both the two as well as the four cycle principle is employed according to the size of the engine, the speed, and power output requirements.

OPERATING CYCLES

To enable more complete understanding of the cycle of operations involved in the conversion of the latent heat energy of a gas into mechanical energy, it is well to note the several stages essential to a complete cycle in order of their occurrence.

*C. B. Ames, V. P., The Texas Company, presented at a National Conference on the Relation of Law and Business, under the Auspices of the School of Law and the School of Commerce, Accounts, and Finance of New York University, October 26 and 27, 1931.

In the four cycle type of gas engines the combustion of fuel begins with the *suction stroke*, wherein the piston moves downward or away from the head of the cylinder, to admit the fuel charge of air and gas through the inlet or admission valve which is mechanically opened.



Courtesy of Clark Brothers Company

Fig. 1—Cross sections through a Clark two-cycle gas engine, direct connected to a compressor. Cylinders are lubricated by pressure feed, bearings being served by a circulating system.

The *compression stroke* follows wherein the piston travels upward or back over this path. All the valves are closed during this stroke, consequently the fuel charge enclosed within the cylinder is compressed, the pressure rising according to the compression ratio.

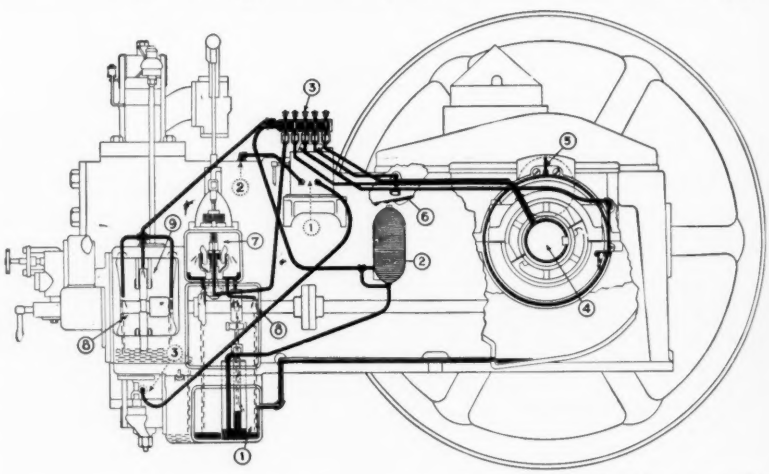
Work is done during the *power stroke* wherein the piston once again travels downward or away from the cylinder head, when the compressed fuel charge is ignited by a spark while all valves are closed. The liberation of heat caused by ignition and explosion develops the increased power necessary to drive the piston and do the necessary work.

The *exhaust stroke* completes the cycle wherein the piston once more travels upward towards the cylinder head, the exhaust valve opening meanwhile to permit of the complete scavenging of the cylinders by expulsion of the exhaust gases while the inlet valve is closed.

It is therefore obvious that four strokes of the piston accompanied by two revolutions of the crankshaft are necessary to complete the cycle of operations.

In the two cycle engine, the four essential stages of a complete cycle which the fuel charge must undergo in its passage through the engine, viz.: admission, compression, explosion and expansion, and exhaust, take place over two strokes of the piston or during one complete revolution of the crankshaft. As a result the number of power strokes per revolution in an engine of this type will be the same as the number of cylinders.

The modern gas engine may be built according to the trunk-piston or crosshead principle. In a trunk-piston engine the connecting rod is connected directly to the wrist pin in the piston and the side thrust, caused by the angularity of the connecting rod, is taken by the piston bearing against the cylinder wall. A crosshead type engine has its connecting rod attached to a crosshead traveling in guides, which crosshead in turn is connected to the corresponding piston. The side thrust caused by the angularity



Courtesy of Joseph Reid Gas Engine Co.

Fig. 2—Oiling diagram of a horizontal engine showing force feed lubricator to serve cylinder and exhaust valves. Note automatic oil pump with PurOlator, distributing oil to all bearings and valve operating mechanisms.

of the connecting rod is taken by the crosshead and guides.

An interesting feature of the gas engine from the viewpoint of heat transfer is that constant volume prevails both in the introduction and abstraction of heat.

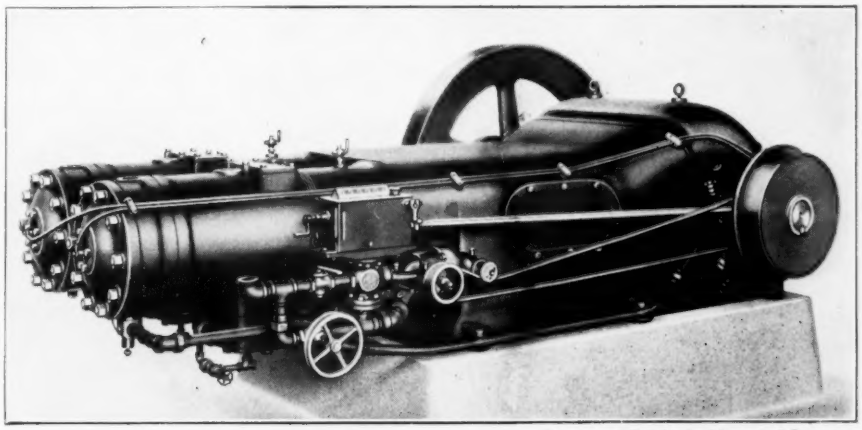
LUBRICATION DETAILS

The gas engine will function most satisfactorily and show a longer period of useful life when it is effectively lubricated. On the other hand, the best of design will be of little avail in lengthening the life of such an engine if the quality of lubrication and the means of application are not properly studied. To the credit of the engine builder it may be said that this has been fully realized.

In order to maintain effective lubrication the operating factors which impose certain duties upon the oils, as well as the various lubricated parts of the engine must also be fully understood by the operators. Simplicity of design, and ready access to all parts have been accepted as fundamental requirements by the builders of the modern gas engines. Particular attention has been given to include completely automatic lubrication, doing away with all complications to assure positive distribution of oil to the various parts. In consequence, standardized lubricating systems are employed, differing in detail only according to the design and constructional conditions of the engine.

The trend in modern gas engine design is to mechanically lubricate every part and to eliminate the hand oil-can as far as possible. As a result the majority of manufacturers are building engines which are entirely automatic in their lubrication. In fact, on engines where some hand oiling is required this has been limited to such parts as the valve gear, cam rollers, fulcrum levers and governors. For the purpose of analysis it is advisable to classify the several parts of the gas engine requiring lubrication into two broad groups, covering:

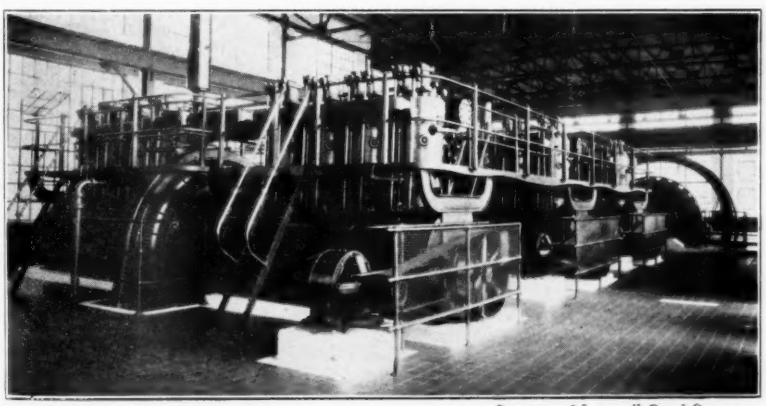
Cylinders and Pistons, and
Bearings or External Parts.



Courtesy of Fairbanks-Morse and Company

Fig. 3—Showing a two cylinder gas engine, with force feed lubricator attached. Cylinders are lubricated through three feeds respectively. Other internal parts of engine are splash lubricated from the crankcase.

Cylinders and Pistons may be served by splash or pressure according to the type of engine. Small vertical high speed units equipped with trunk pistons are sometimes lubricated by the splash method whereby oil is thrown from the bearing systems. The crosshead type, and the larger trunk piston engines, both vertical and horizontal will most usually have their cylinders lubricated by mechanical force feed lubricators which can be adjusted to handle a uniform quantity of oil at a regular rate of delivery.

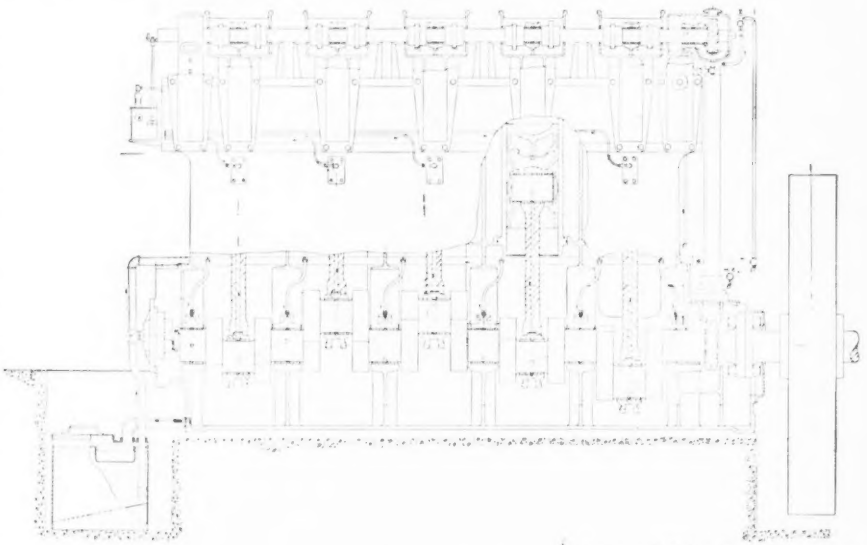


Courtesy of Ingersoll-Rand Company

Fig. 4—Showing view of an installation of three 8-cylinder, 1000 h.p., vertical gas engines. Note compactness of engine room.

Bearings of the connecting rod, crank pin, piston pin, and main elements are usually pressure lubricated by one grade of oil throughout, although the main outboard bearings of some vertical engines may be ring oiled.

The fact that these are standardized means of lubrication should not relieve the operator of realizing that probably no other type of machine can be damaged so easily and quickly by faulty lubrication as the modern gas engine. This applies particularly to the use of inferior oils. While the average cost per unit of power to lubricate any such engine is small, this cost can very quickly be increased beyond all reason by the use of an unsuitable grade of lubricating oil which will not afford the necessary protection, to result in abnormal wear and increased maintenance costs.

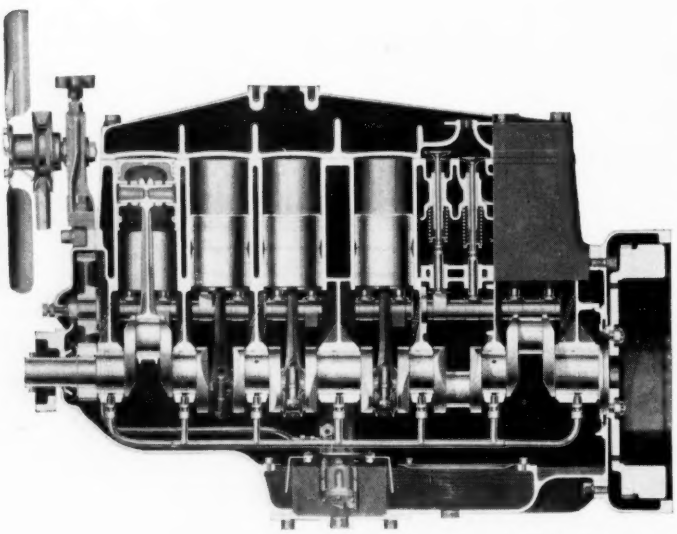


Courtesy of Fulton Iron Works Co., Inc.

Fig. 5—Sectional details of a heavy duty power plant gas engine. Cylinders are lubricated by metering force feed pumps, with two feeds for each cylinder. Bearings are served by a positive pressure circulating system.

In average service the operating conditions pertaining to lubrication and the parts affected are indicated as follows:

Conditions	*Parts*
1. High rubbing velocity with moderate pressures.	Main bearings, crank pins.
2. Low rubbing velocity with high pressures.	Wrist pins.
3. Low pressures with intense heat.	Pistons, cylinders.
4. Miscellaneous relatively small parts lightly loaded as a rule, but requiring a complexity of feeds.	Cam shafts, rocker arms, auxiliary drives.



Courtesy of Hercules Motors Corporation

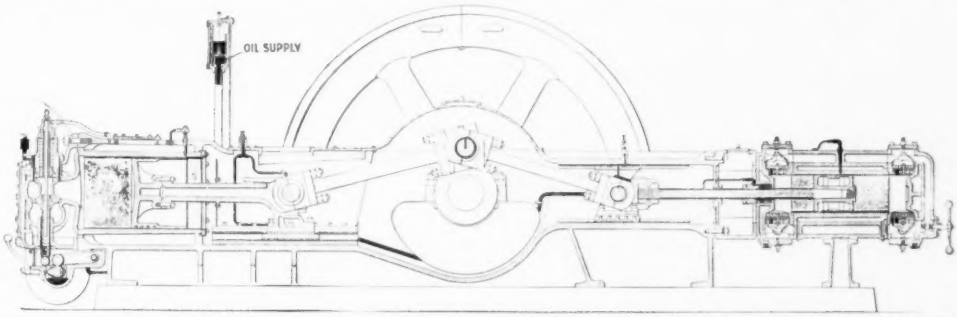
Fig. 6—Cut-away view of a convertible engine, capable of operating on either liquid or gas fuel. Lubrication is accomplished by oil circulated under pressure.

In view of the fact that the above parts will involve materials in motion with respect to one another which will often differ widely, the prevailing range of pressures, speeds and temperatures, coupled with the coefficients of friction of the materials used in the average engine, would seem to require a number of different grades of oil to insure its operation. Judicious selection of products especially refined to meet such conditions has proved, however, that from one to two oils will serve the purpose.

There are, of course, plants where more will be necessary, the constructional conditions dictating too wide a viscosity range for any one lubricant. Investigation has indicated that even this condition can often be eliminated, especially on small sized engines, if the means of application is studied. Experience has proved that it is perfectly practicable to refine lubricating oils which, provided an engine is properly cooled, will meet the intensive duty involved in the cylinders, and still be of the

right viscosity at prevailing bearing temperatures adequately to serve these latter parts.

Gas engine lubrication must be positive and any oil used capable of developing a sufficiently



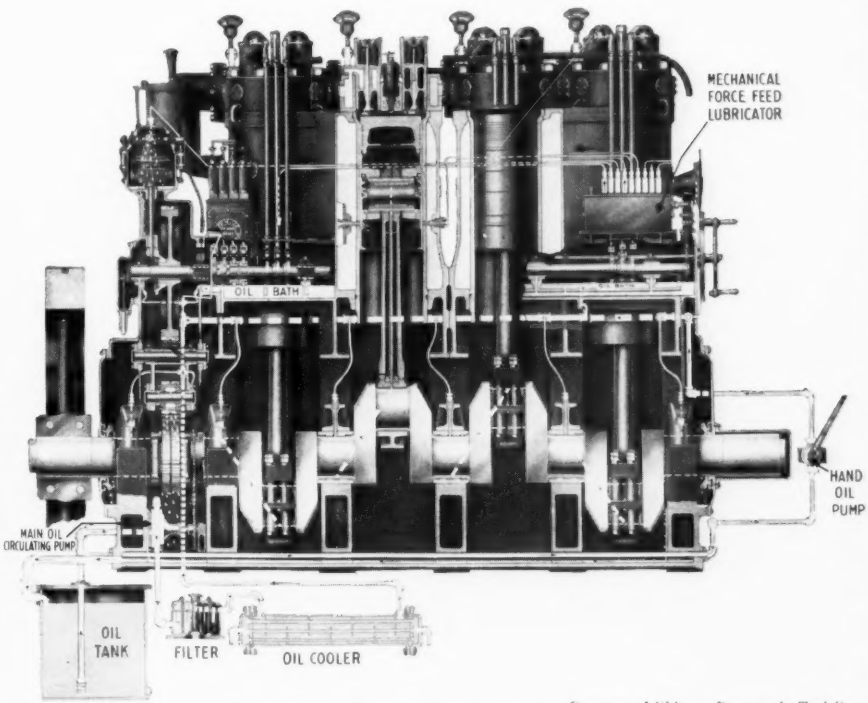
Courtesy of The Miller Improved Gas Engine Co.

Fig. 7—Diagrammatic view of a Watts-Miller heavy duty gas engine, showing details of oil circulation.

tenacious lubricating film to withstand the prevailing operating pressures. The selection of lubricants for a gas engine plant should, therefore, be made strictly on the basis of quality, involving chemical characteristics to insure properly refined oils containing no impurities, and on viscosity, to insure the proper grade.

Neither color nor density qualify as special properties in the selection of such an oil, although color may be significant of the degree of refinement. When light, medium or heavy oils are mentioned, it is the viscosity which should be borne in mind; "light" referring to low viscosity, or a range say from 150 to 350 seconds Saybolt at 100 degrees Fahr., "medium" indicating a range from 350 to 500 seconds, and "heavy" all oils of heavier body.

Excessive friction may result from the use of an oil of either too high or too low viscosity. Too high a viscosity will give a good film but the internal friction in the oil may be excessive; conversely, if the viscosity is too low the film may be broken. The physical characteristic, viscosity, therefore, is of supreme importance in the selection of a lubricant, as it is a measure of the ability of the oil to maintain the proper film under the existing conditions of speed, pressure and temperature. This has been the basic thought in the preparation of the lubrication recommendation chart.



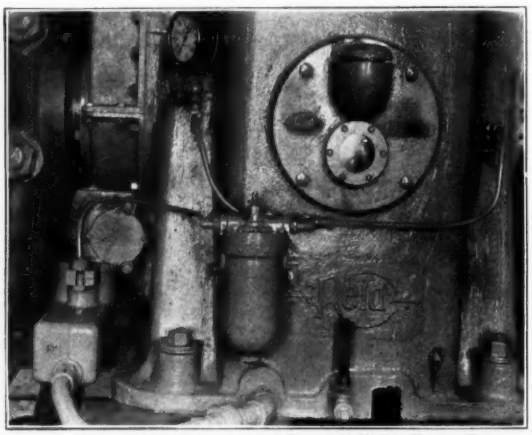
Courtesy of Chicago Pneumatic Tool Co.

Fig. 8—Cut-away view of a vertical 4-cycle convertible Diesel or gas engine, showing lubrication details. Oil is taken by the main oil circulating pump from the oil tank through the filter and oil cooler, being distributed to the bearings as indicated by arrows. An auxiliary hand oil pump is shown at the right of the engine, which is used to build up an oil supply on the bearings when starting. Cylinders are served from a mechanical force feed lubricator, with two points of oil supply to each cylinder as shown. Cam mechanisms are lubricated by an oil bath.

LUBRICATING SYSTEMS

There are a number of systems commonly employed for the lubrication of gas engines, and often a combination of two or more may be fund on the same engine. Frequent practice is to embody two separate distinct lubricating

systems, which may be designated as the high and the low pressure systems. The former includes the provisions for supplying lubricating oil to the power cylinders, while the latter serves oil to the various bearings throughout the engine. On some engines a third system may be used solely for lubricating the crosshead pins with oil under high pressure or for serving the outboard bearing. A certain amount of hand oiling may also be required to take care of the valve mechanisms and small external bearings that require a relatively slight amount of oil.



Courtesy of Joseph Reid Gas Engine Company

Fig. 9—Close-up view of pressure oiling equipment as applied to a 2-cycle gas engine.

The modern gas engine builder equips his units with oiling systems according to the type, size and number of revolutions. No one type is best for every service, although the force feed system has become one of the most general methods. Other systems involve pressure circulation, splash oiling, gravity feed, ring or chain oilers, and oil throw.

These various lubrication systems may be grouped as follows, with respect to the parts to which they are adapted:

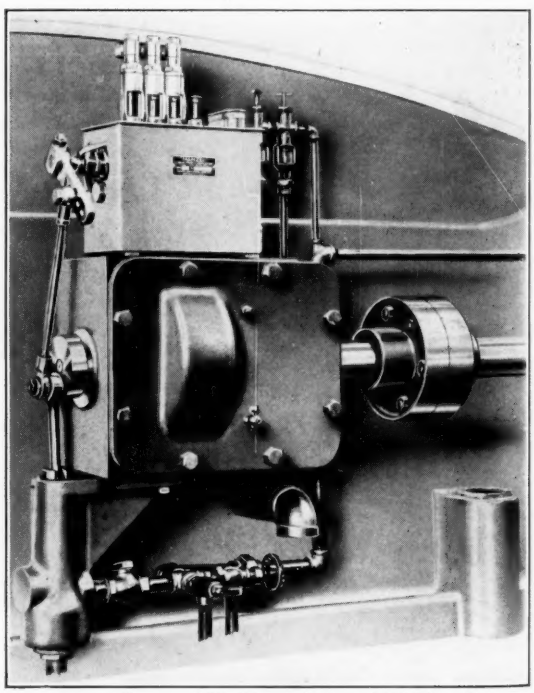
Cylinders	*Bearings*
1. Mechanical Force Feed	Mechanical Force Feed
2. Mechanical Force Feed (With oil throw)	Pressure Circulation
3. Mechanical Force Feed (Without oil throw)	Pressure Circulation
4. Mechanical Force Feed	Gravity or Ring Oiling
5. Oil Throw	Pressure Circulation
6. Pressure Circulation	Pressure Circulation
7. Splash	Splash

Where pressure is involved to insure that the engine shall be liberally supplied with lubricating oil from the first move, an attachment or crank can be located in the lubrication system so that all the pipes and bearings can be primed by manual operation of the lubricator pump. This same objective can also be attained by installing check valves in the delivery pipes as near as possible to the outlet ends. Such valves prevent loss of oil and emptying of the pipes when the engine and oil pump stop operating, insuring retention of oil in the pipes to enable adequate lubrication when operation is resumed.

Mechanical Force Feed Lubricators

Pressure lubrication is perhaps the most popular means of delivering oil to the cylinders and piston, and packing glands of a gas engine. Force feed lubrication as applied to cylinders and pistons can be regarded as high pressure lubrication, inasmuch as pressures as high as 1,000 pounds per square inch are employed, in comparison with the relatively low pressure systems used for the miscellaneous bearings of certain types of engines.

With mechanical pressure or force feed lubrication each lubricator contains a number of individual adjustable pump plungers receiving their oil supply from the lubricator reservoir. They feed accurately measured quantities of oil to meet the requirements of the parts being lubricated. Sometimes provision is made for lubricating the piston pins by the same means,



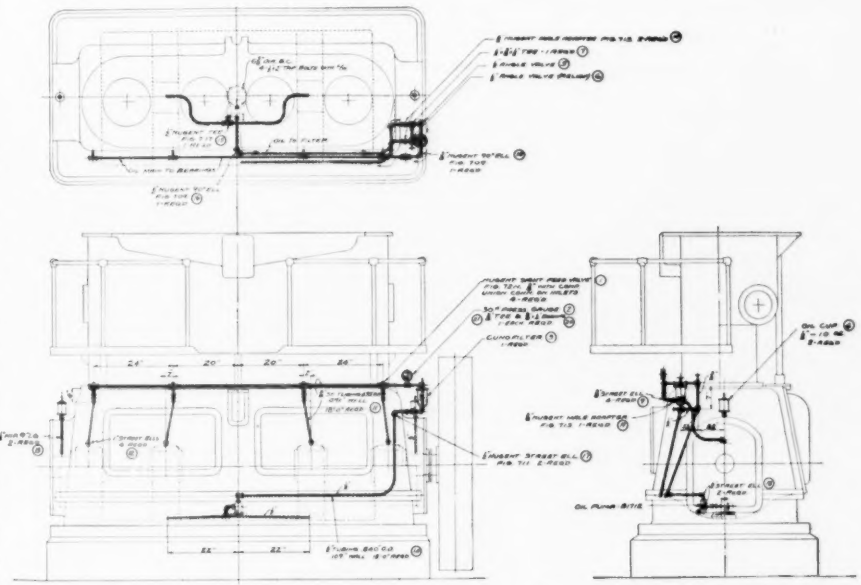
Courtesy of Worthington Pump and Machinery Company

Fig. 10—View of an oil pump and lubricator installation for a single cylinder gas engine.

although these latter may be equally well lubricated by the bearing circulation system. Several leads are usually employed to conduct the oil to the cylinder walls, the number depending on the size of the cylinders, and whether they are located horizontally or vertically.

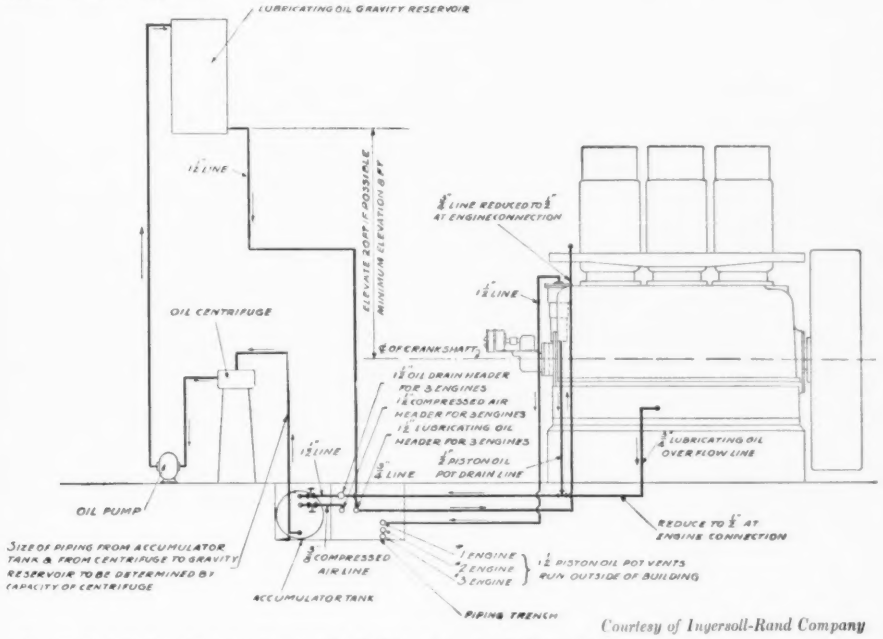
Where mechanical force feed lubricators are used in connection with main bearings and other rotating elements the latter are flooded with a continuous and adequate supply of oil which assures the formation and maintenance of a complete lubricating film at all times. A mechanical force feed lubricator, being practically always driven by the machine which it serves, only functions when the latter is in operation and at a proportional speed. The pumping capacity and rate of oil feed is, therefore, variable. By suitable adjustment of the lubricator it can be very accurately regulated to meet whatever lubricating requirements the moving parts may involve.

On small type gas engines mechanical force feed lubrication may be readily employed to serve the bearings as well as the cylinders. Oil so fed to the bearings may be recovered from the engine crankcase, filtered, and cooled, and returned to the mechanical lubricators for recirculation, especially where bearing temperatures are not sufficiently high to cause vaporization and marked increase in the viscosity of the oil.



Courtesy of The Bruce-MacBeth Engine Co.

Fig. 11—Views of a vertical multi-cylinder gas engine, showing piping details pertinent to lubrication.


LUBRICATING OIL GRAVITY RESERVOIR
1½" LINE
ELEVATE 20 FT. POSSIBLE MINIMUM ELEVATION 8 FT.
¾" LINE REDUCED TO ½" AT ENGINE CONNECTION
1½" LINE
OIL CENTRIFUGE
℄ OF CRANKSHAFT
1½" OIL DRAIN HEADER FOR 3 ENGINES
1½ COMPRESSED AIR HEADER FOR 3 ENGINES
1½ LUBRICATING OIL HEADER FOR 3 ENGINES
½ PISTON OIL POT DRAIN LINE
¾" LINE
¾ LUBRICATING OIL OVER FLOW LINE
1½" LINE
OIL PUMP
REDUCE TO ½" AT ENGINE CONNECTION
SIZE OF PIPING FROM ACCUMULATOR TANK & FROM CENTRIFUGE TO GRAVITY RESERVOIR TO BE DETERMINED BY CAPACITY OF CENTRIFUGE
⅜ COMPRESSED AIR LINE
1 ENGINE
2 ENGINE
3 ENGINE
½ PISTON OIL POT VENTS RUN OUTSIDE OF BUILDING
ACCUMULATOR TANK
PIPING TRENCH

Courtesy of Ingersoll-Rand Company

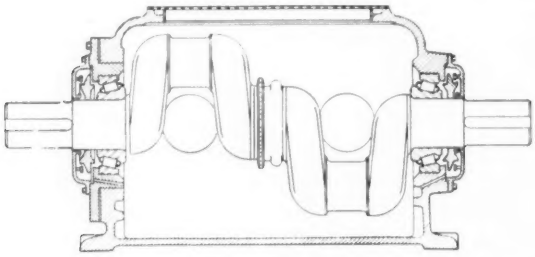
Fig. 12—Lubricating oil piping diagram of a Rathbun-Jones 3-cylinder vertical gas engine.

Pressure Circulation Systems

The continuous circulation of oil through bearings affords a very practical and economical way of automatically lubricating such parts with a minimum of labor and attention. As a rule, a considerably greater volume of oil will be involved in a circulating system than in a mechanical force feed lubricator.

A typical circulating system as designed for gas engine service will involve a suitable oil

reservoir in the base of the engine, a pump of the geared or plunger type for transmission of oil either to an overhead auxiliary tank, or directly to the bearings to be served, with the necessary distributing pipes to each of the



Courtesy of The Cooper-Bessemer Corporation

Fig. 13—Section through a twin cylinder gas engine, showing application of roller bearings to main bearing elements.

latter where an overhead tank is used. Each line should be fitted with a sight feed device and adequate means for individual adjustment of oil flow. Means will also be necessary for drainage or transmission of used oil back to the base reservoir or sump tank. Where oil is fed directly to the bearings from the pump, a relief valve is necessary to enable return of surplus oil to the sump.

Pressure circulation is advantageous in that it provides for sufficient settling of the oil to insure precipitation of the greater part of any foreign matter that may have been picked up by the oil in passage through the bearings. Furthermore, since the latter are practically flood lubricated, they will not only be washed free from accumulations of foreign matter, but also cooled to a certain extent.

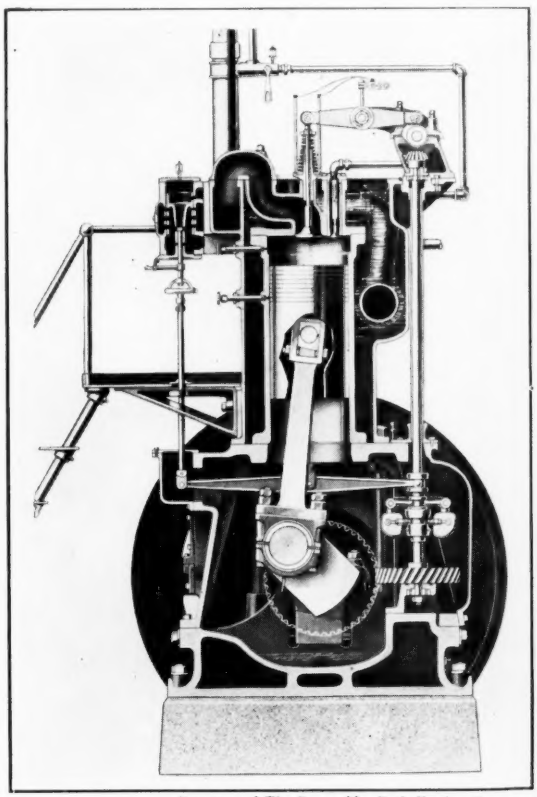
It is also perfectly practicable to provide for adequate pressure either by gravity or pumping, to maintain a sufficient pressure on the oil films which partly serve to resist such operating or reaction pressures as may be involved on certain of the bearings. It is also practicable to equip the pressure gauges of the lubricating system with both high and low pressure alarms to call the engineer's attention to pressure changes beyond permissible limits.

Direct pressure circulation is admirable for lubricating the various bearings of gas engines. A resume of a direct system would show a circulating oil pump driven off the engine to deliver the oil under pressure to the main bearings and through ducts to the crank pins, crosshead guides, piston pins, tail rod supports and secondary bearings, according to the type of engine. After passing through the bearings the oil drops back into the crankcase from which it is pumped to a filter or other purifying device from which the oil is again recirculated through the system. In order to keep the oil at or near a constant, moderate temperature, water cooling coils are sometimes employed to dissipate the heat acquired during circulation through the system.

Splash Oiling

Splash lubrication is adaptable to small, high speed vertical engines where the circulating oil for the bearings also furnishes lubrication for the cylinders. In this type of system the cylinders depend primarily for their lubrication upon the oil thrown or splashed from the crankcase. During each stroke an oil film is formed on the lower part of the piston and cylinder walls which is distributed on each successive upward stroke by the piston rings. The oil drains continually by gravity to the reservoir within the crankcase.

Efficient lubrication results in such engines because of the liberal amount of oil thrown from the moving parts as it passes through the bearings. For such service a highly refined minimum carbon residue content oil is recommended, having a viscosity in the neighborhood



Courtesy of The Bruce-MacBeth Engine Company

Fig. 14—Cut-away view of a vertical gas engine, designed for enclosed crankcase lubrication.

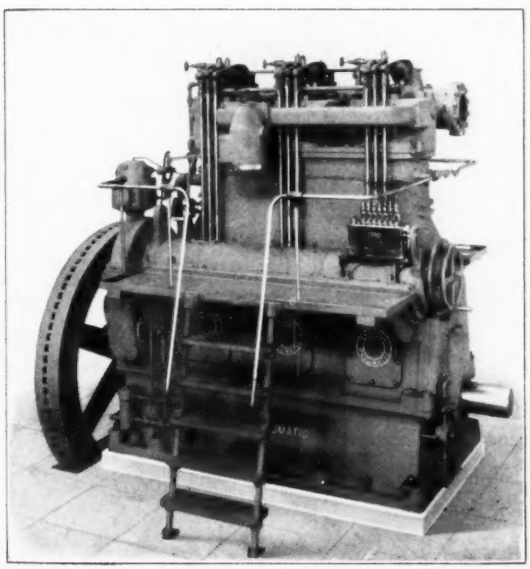
of 300 to 500 seconds Saybolt at 100 degrees Fahrenheit.

To enable proper and continuous distribution of oil, the sump or base of the crankcase

must be kept filled to the proper level, which can be automatically maintained by installation of a suitable gauge glass and overflow. This will enable the bottom ends of the connecting rods to dip and either splash or otherwise distribute oil (through suitable ducts) to all interior parts.

It is important to remember that an excess of oil may lead to abnormal carbon deposits, particularly around piston rings if the level in the case is kept too high and abnormal splash prevails. Location of the overflow should, therefore, be given careful consideration. The objections to splash with accompanying possibility of carbon accumulations may be overcome by using a system of oil throw. Here provision is made for oil as it is circulated through the crank bearings to escape and be subsequently thrown to the cylinder walls in sufficient quantities to assure adequate lubrication.

Protection of the oil in the crankcase can be insured, and carbonization of oil around the piston rings (especially where the cylinders are splash lubricated) can be prevented by locating a drain-off connection at the base or inboard end of each cylinder. Any excess oil on the cylinder walls between the bottom follower ring and the scraper ring is accumulated between these two on the down stroke and directed



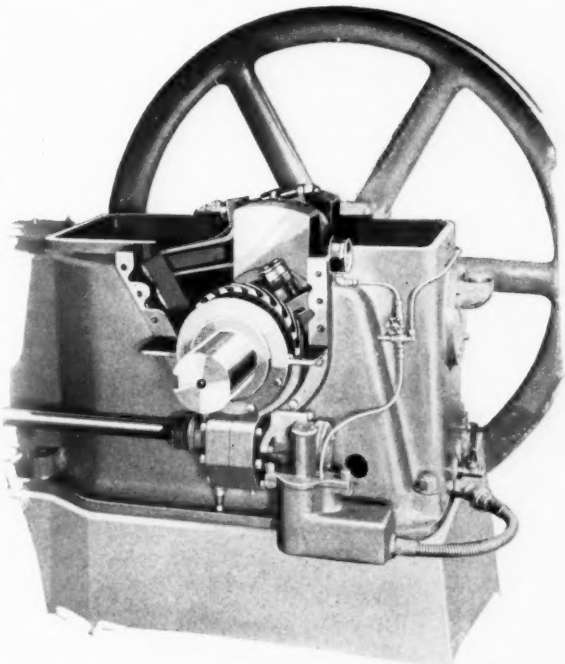
Courtesy of Chicago Pneumatic Tool Company

Fig. 15—External view of a 3-cylinder vertical gas engine, showing location of the mechanical force-feed lubricator which serves the cylinders.

to the drain-off. Experience has indicated that a considerable amount of water developed during the process of combustion can thereby be prevented from entering the crankcase. Study of the oil accumulated will also indicate marked reduction in lubricating value due to oxidation and sludge accumulation.

Ring and Chain Oilers

The lubrication of main as well as outboard bearings in certain types of engines is sometimes



Courtesy of Joseph Reid Gas Engine Company

Fig. 16—Oil pump details of an enclosed two cycle gas engine with gear uncovered.

accomplished by the use of ring oilers. With such a device a continual delivery of oil is assured to the contact surfaces by means of a ring suspended from the shaft, and free to rotate therewith, the lower part dipping in a bath of oil which is carried in a suitable reservoir in the lower part of the bearing shell. Normally this will circulate oil under practically no pressure.

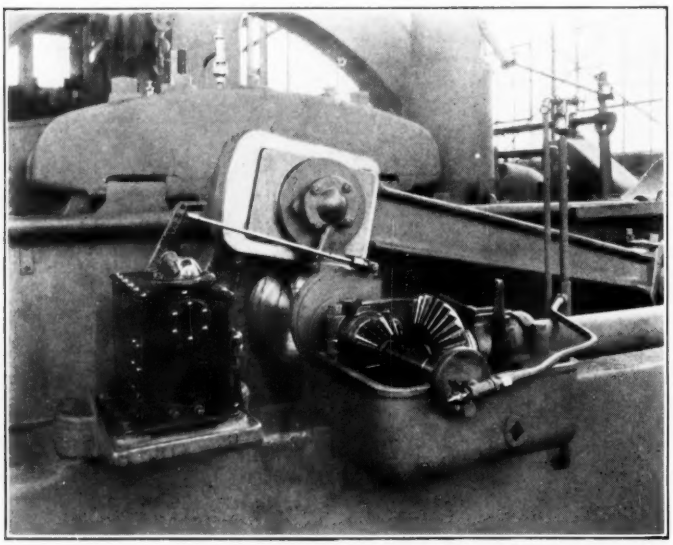
In order to insure effective lubrication the reservoir must be of adequate capacity to give the oil ample opportunity to rest, thereby making possible not only the settling out of sediment and other foreign matter, but also cooling to the requisite degree. As a rule, the only way in which the oil in such a system is kept at the proper temperature is by radiation of heat from the interior surfaces of the reservoir or lower part of the bearing.

Oil which is carried to the top of a ring oiled bearing must be returned to the reservoir as rapidly as it is delivered by the ring in order to avoid accumulation of oil in the upper part of the housing, and leakage from the ends of the bearing. The same condition may arise if the oil is carried too high in the well, or if the ring

rotates at too high a speed. This will cause a splashing and churning of the oil.

CYLINDER LUBRICATION

Gas engine cylinder lubrication must be given most careful study by reason of the prevailing high temperatures. In part, these will be offset by effective cylinder and piston wall cooling It is impossible, however, to reduce such temperatures sufficiently to absolutely protect the lubricating film against at least partial breakdown and vaporization; especially since this will be aided by the normal thinness of such a film in contrast with the area covered, and the scraping action developed by the piston rings. Continuous renewal of the lubricating film, especially where a mechanical force feed lubricator is employed, is the best solution of the problem, for it enables restoration of lubricant before vaporization or breakdown losses occur sufficiently to develop actual metallic contact. This can only be positively assured, however, provided the oil is of the proper viscosity to resist the reducing effects of heat, and shows a sufficiently low carbon residue content to preclude abnormal development of carbon deposits.



Courtesy of The Cooper-Bessemer Corporation

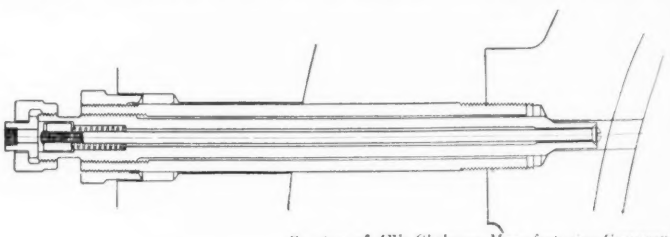
Fig. 17—Showing an eccentric connection on the drag-crankshaft of a gas engine, which operates a force-feed lubricator for oiling the power and compressor cylinders, and drives a plunger pump for lubricating all bearings.

Actual formation of such deposits will be brought about in much the same manner as in the liquid fuel type of internal combustion engine. There will, however, be but little possibility of this being aggravated by the type of gas used as fuel unless the dust or tar content is comparatively high, when the same results might be expected as occur when a liquid fuel is subjected to incomplete combustion. The detrimental features which may accrue from the use of contaminated gas cannot be overlooked. Not only will they involve fouling of the valves with the possibility of sticking, but also there will be the probability of increased cylinder wear. This will be brought about by accumulation of the foreign matter content of the gas around the piston rings. Should an unsuitable grade of lubricating oil be used, it would be logical to expect such formations to be increased by the carbon residue content of the former. Under the prevailing temperatures these formations might develop into hard, abrasive encrustations, although the degree of hardness of the carbon resulting from the lubricating oil will depend upon the base. The actual percentage of carbon residue content, however, will be a function of the manner and degree of refinement to which the lubricating oil has been subjected. Unfortunately, there is no oil which will not deposit some carbon: on the other hand, there is a surprising difference in the nature and quantity of this carbon which will be developed by different oils.

Consequently, not only must an oil be most carefully selected, but also, whatever its characteristics, the utmost care should be taken to prevent the use of more oil than is necessary.

The Detriments of Carbon Accumulations

An excess of oil fed to the engine cylinders may bring about leaky valves due to a certain amount of oil becoming carbonized on the latter. Likewise, an excess delivered to the piston rod stuffing box may cause leakage and improper functioning of the packing due to abnormal wear. Carbonaceous matter, being relatively sticky in the early stages of its formation, will also tend to adhere to the piston rings, thereby causing them to become in-

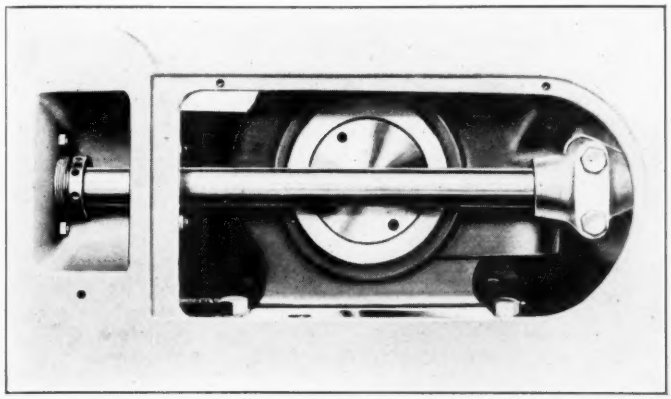


Courtesy of Allis-Chalmers Manufacturing Company

Fig. 18—Showing section through cylinder oiling check valve for an Allis-Chalmers gas engine.

operative; furthermore, it will tend to destroy the lubricating film and result in scored cylinders.

Carbon, as an essential element in the make-up of any petroleum product is present in more or less intimate chemical connection with hydrogen. There is a distinct difference between carbon as it exists in this manner and carbon as it is found in actual operation in the form of coke or carbon residue. In the former instance the complex-hydrocarbons involved have a high degree of oiliness. They have, therefore, proved themselves as most adaptable lubricants. Coke or carbon residue developed as a result of break-down of certain of these hydrocarbons under high temperature, however, has no lubricating value whatsoever. In fact, the resultant material is even a particularly poor grade of carbon. The nature of this latter from a physical point of view will depend upon the base of the crude from which the lubricant has been refined.



Courtesy of Worthington Pump and Machinery Corporation

Fig. 19—Showing telescopic piping on the crosshead for cooling water circulation to piston and piston rod.

As a result, carbon residue as it may appear in the operation of the gas engine will be found to vary widely in its degree of hardness and adhesiveness. Whatever its residual form, however, it is always important to remember that carbon, as it results from the break-down of any lubricating oil, is not a lubricant and therefore may develop into a decided abrasive and do a considerable amount of damage to the working parts.

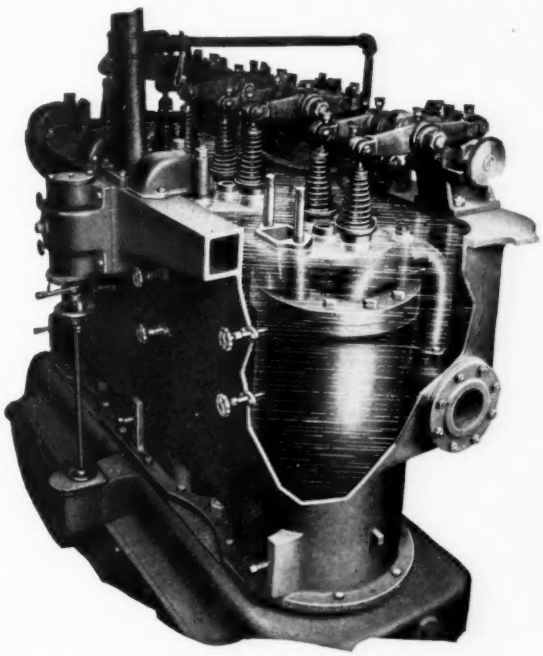
It may also accumulate around the piston rings and prevent free operation of these elements. The extent to which this latter may occur, or in fact, accumulation of any excessive amount of carbon residue in the gas engine, will depend on the base of the crude, as already stated. In this connection it is interesting to note that the more nearly naphthenic base oils have been found to give a carbon residue of a comparatively soft, fluffy nature, which normally can be easily removed by brushing. It is reasonable to presume that carbon of this nature will oftentimes be very largely removed from the engine by the exhaust before it has a chance to accumulate within the latter.

On the other hand, certain paraffin base oils if not properly refined will develop a carbon residue which will be of a comparatively hard and adhesive nature. Their use may lead to serious accumulations which may require virtually complete engine overhaul for their removal.

Effect on Power

Accumulation of carbon deposits in the gas engine will be primarily indicated by loss of power, just as holds true in any other type of internal combustion engine.

In the gas engine there will be somewhat the same tendency to develop knocking, due to the manner in which the fuel is handled. As a result, it will be essential for the operator to pay strict attention to the power out-put and sound of his engine.



Courtesy of The Bruce-MacBeth Engine Company

Fig. 20—Cut-away view showing a method of bringing about water cooling without using water jackets.

Power out-put can be readily observed in connection with such an engine, in view of the fact that it is generally stationary and therefore readily adapted to the installation of power measuring instruments.

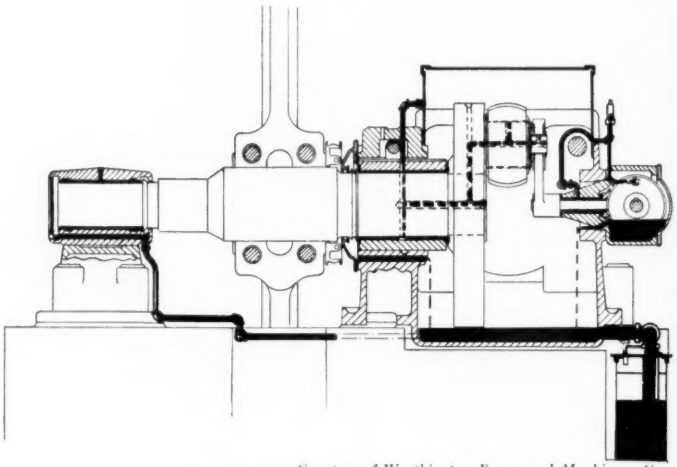
The tendency of carbon deposits to become incandescent may be the cause of pre-ignition or back-firing in the gas engine. Back-firing will be indicated by an explosive noise in the intake or supply line. It may lead to reduction in power output if allowed to occur to an excess. It can frequently be corrected by analysing the gas and studying the richness of the mixture to eliminate any tendency towards slow burning and the presence of lingering flame or incandescence in the combustion chamber to ignite the fresh charge of fuel prior to completion of the intake stroke and closing of the inlet valve.

Pre-ignition is chiefly caused by an overheated condition. Inasmuch as it involves explosion before completion of the compression stroke it is the direct cause of loss of power, due to the reverse energy exerted. If allowed to develop to an extreme, breakage of connecting rods or some other working part might occur. Pre-ignition will be indicated by a knocking noise. In view of the fact that it is caused by an overheated condition, one should study the carbon-forming tendencies of the lubricating oil, the ability of the cooling system adequately to reduce the cylinder wall and piston temperatures, and the dust content of the fuel. Both carbon and dust accumulations may become incandescent if the cooling system is inadequate, or if the cooling water is circulated at too high a temperature. Dust may be particularly aggravating when blast furnace gas is used due to the prevalence of lime, coke and ore dust in the gas itself.

The relation of proper lubrication to pre-ignition is also indicated where imperfect sealing of the piston rings may prevail. Here, leakage of the gaseous mixture past the rings is claimed to lead to pre-ignition. This may result from use of too light a bodied oil, insufficient cooling, which would cause the oil film to thin out, or carbon accumulation around the rings to interfere with their functioning properly in their grooves.

COOLING—THE RELATION TO LUBRICATION

In order to permit free movement of the piston in the modern gas engine with minimum development of friction over the cylinder walls, and reduction of heat to prevent incandescence, pre-ignition and backfiring, both elements must be cooled. Adequate cooling of cylinders insures against the oil becoming so thinned out by increased temperature as to lead to actual metal-to-metal contact between the piston rings and cylinder walls. Other potential troubles would include distortion due to unequal expansion under the prevailing temperatures, excessive wear due to metallic contact and ultimate seizure of the piston, as well as power losses due to pre-ignition or backfiring.



Courtesy of Worthington Pump and Machinery Corp.

Fig. 21—Section through main and outboard bearings of a horizontal 4-cycle double acting gas engine, showing details of pressure lubricating system.

Piston cooling is in turn essential to prevent undue accumulation of carbon deposits. This would be bound to occur were the lubricating oil exposed to the prevailing high temperatures and pressures with no provision for cooling. Piston cooling can be brought about by circulating water through a suitably designed cooling system or by means of air. Water cooling must be used on the crosshead type of enclosed construction. Certain smaller types of trunk pistons, where directly exposed to air, can be cooled by this latter medium.

Water cooling is the most practicable, however, for larger engines of higher horse power, due to its adaptability; also to exhaust valves and piston rod packing glands. Adequate cooling of exhaust valves will promote increased life by adding to their heat resisting ability. There is a more direct tie-up, however, with lubrication in the case of piston rod glands. Here, if temperatures are allowed to run too high, carbonization of oil may occur which may place a severe load upon the metallic packing of the glands to such an extent as to cause abnormally rapid wear with premature leakage.

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